LA-UR-22-32534

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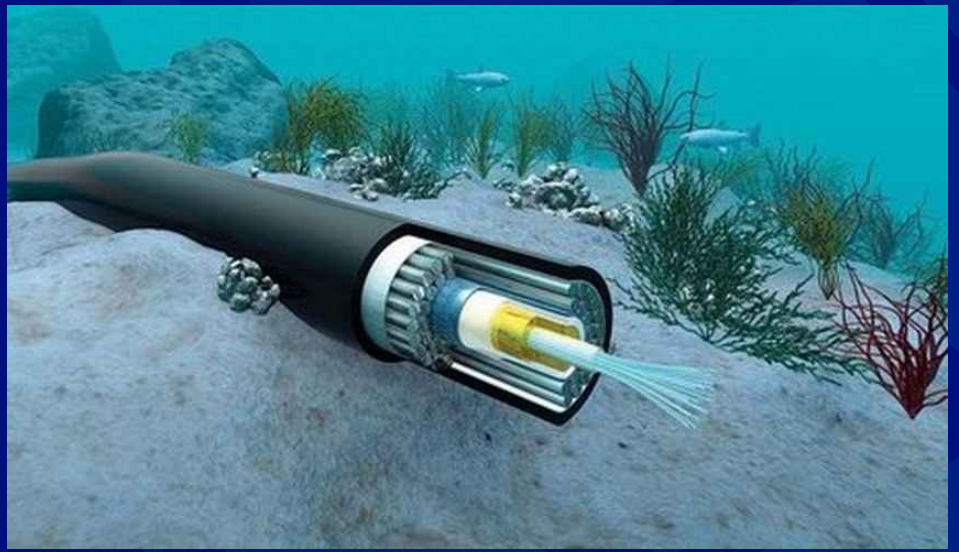
Title:	The SMART Cables Initiative for Ocean and Geophysical Observing
Author(s):	Rowe, Charlotte Anne Howe, Bruce Joint Task Force, SMART Cables
Intended for:	Virtual talk in Sandia National Laboratory seminar series
Issued:	2022-12-02

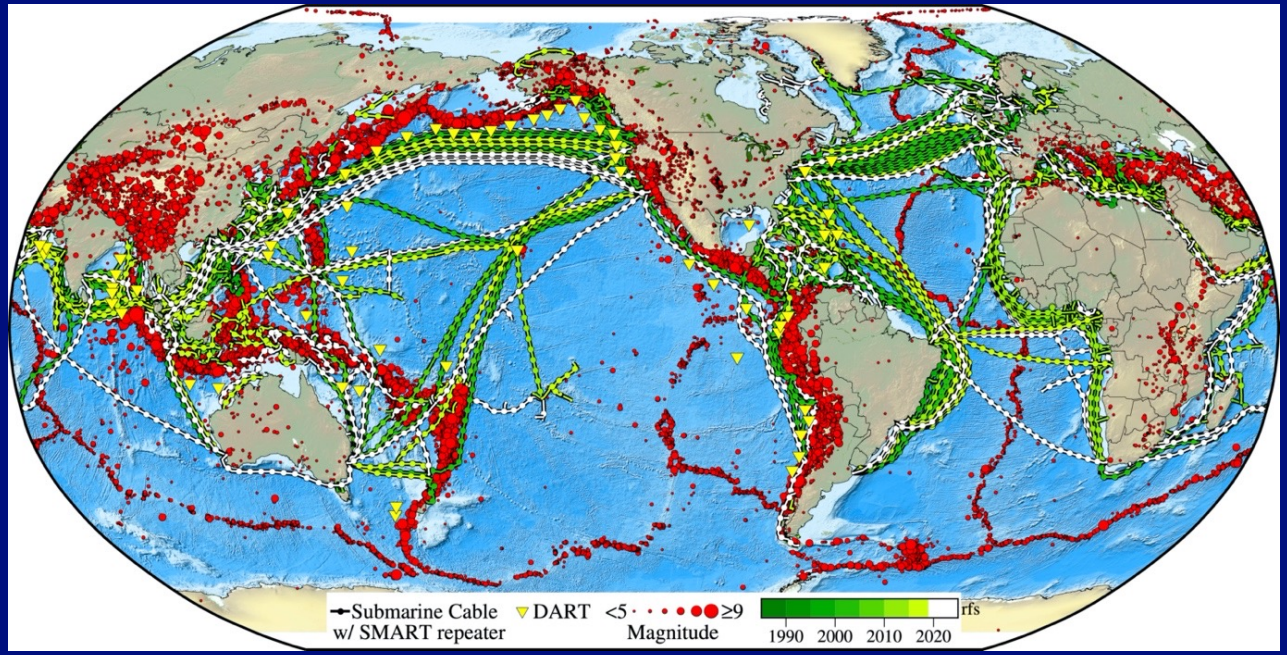
The SMART Cables Initiative for Ocean and Geophysical Observing

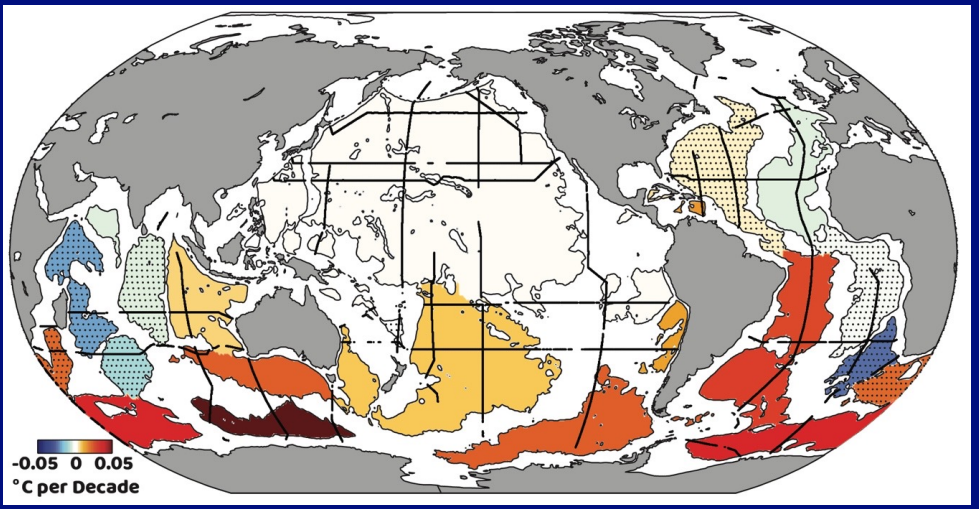
Rowe, C.,A., B. Howe and the SMART Cables Joint Task Force (UNESCO)



There are currently over 1 million km of transoceanic telecommunications cables. Given the current paucity of sensors in the oceans, the aspiration is that these cables will eventually host oceanographic and geophysical sensors along their lengths.

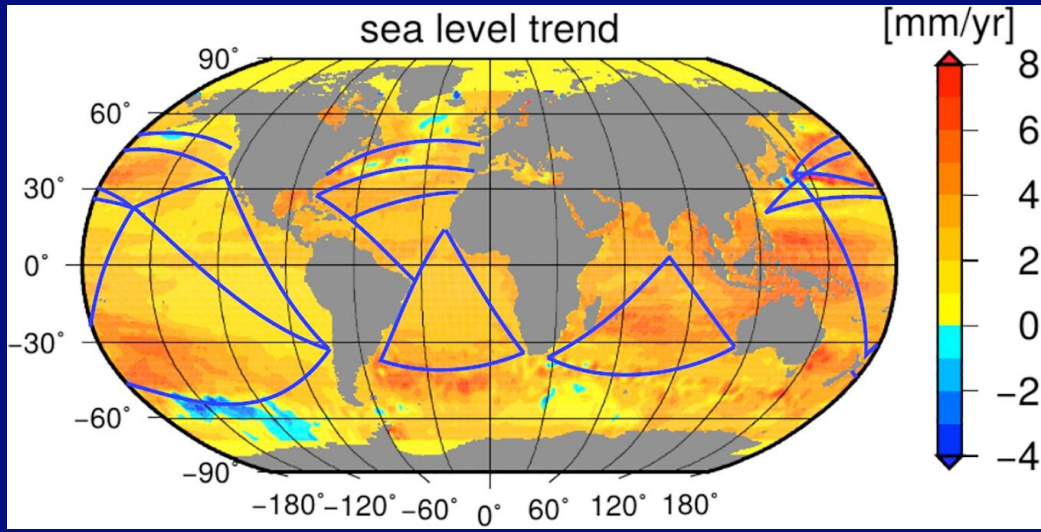
The aim of the Science Monitoring and Reliable Telecommunications (SMART) Cables initiative is to exploit this vast infrastructure for planetary-scale monitoring of oceanic and geophysical parameters, harbingers of climate change impacts, and hazard mitigation and early warning.





Isolated, repeated transects of seafloor temperature have led to coarse models of temperature changes over many years, but continuous in-situ measurements at finer geographic spacing is important for more accurate tracking of ocean temperature change. Thermal changes also alter hydroacoustic propagation and should be accommodated in new models.

High resolution monitoring of sea level change, driven both by thermal expansion and polar melting, is important from a variety of natural hazards perspectives.



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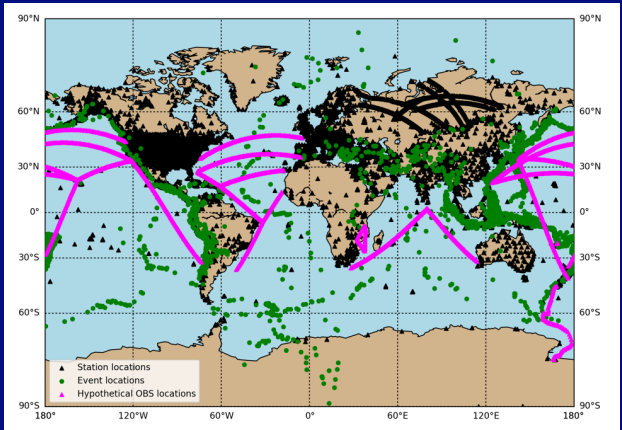
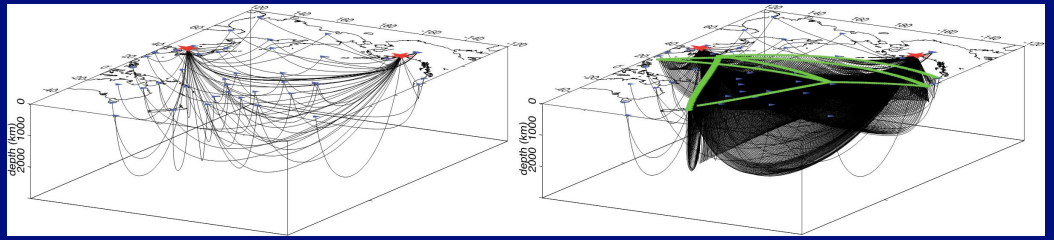
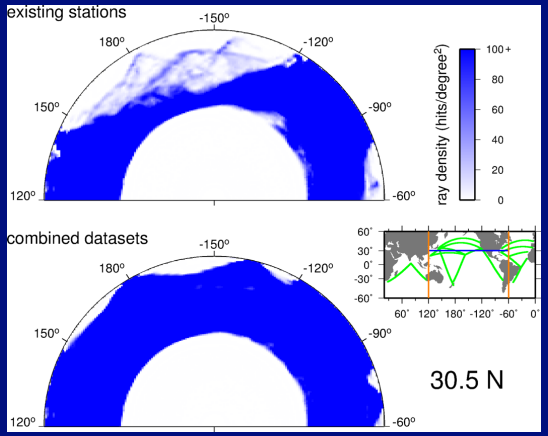
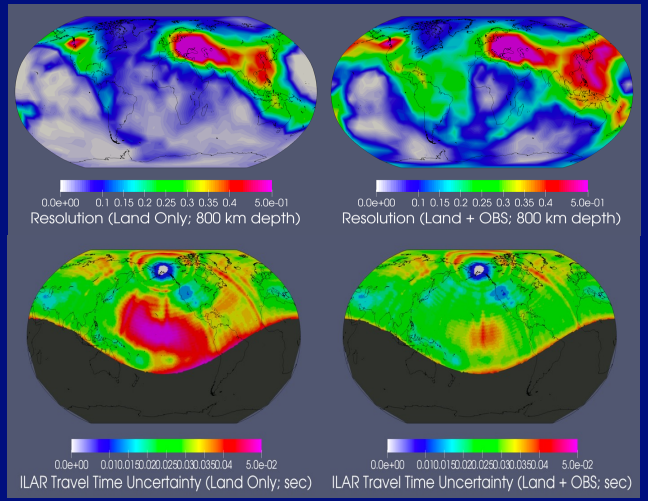


Left: Potential advantages for seismology to expand a largely land-based network to add transoceanic sensing
Below: Example ray density enhancement in Pacific



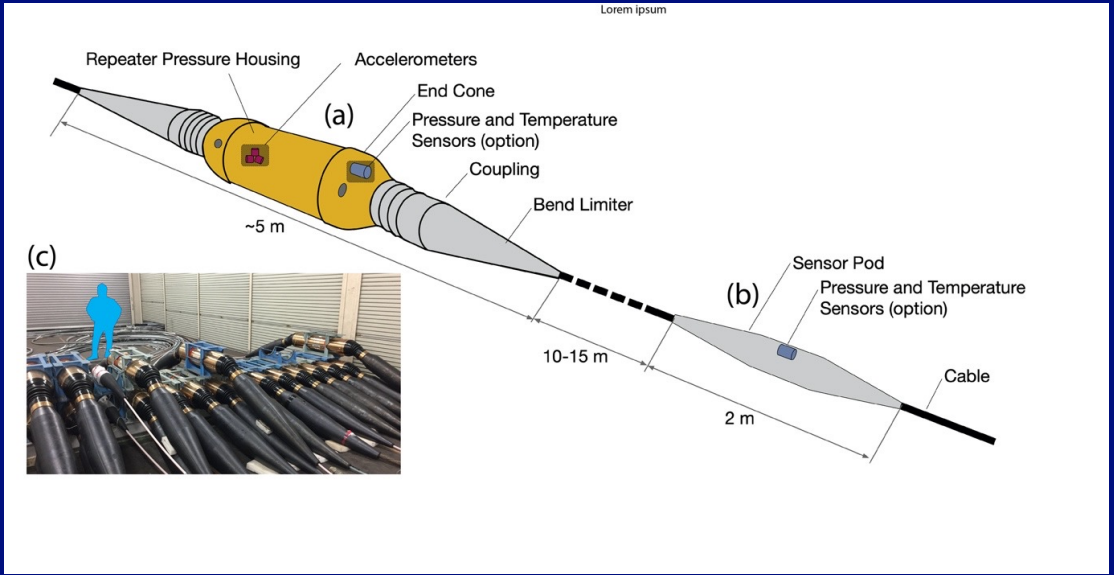


Left: Global cross-section shows improved ray coverage beneath Pacific basin. Right: improved model resolution (top) and travel-time uncer-tainty (bottom) when SMART cables are added to global seismic network for the Sandia LoS Alamos 3D (SALSA3D) global model.



The SMART Cables Joint Task Force (JTF) engineering committee has outlined a prototype for the SMART repeater, which would contain or support a preliminary suite of seismic, pressure and temperature sensors.

Although the vision for SMART receivers and their sensor packets is a standardized instrument suite, current demonstration projects are testing a variety of flexible configurations, including the possibility of added ancillary sensors. Moving forward, although transoceanic deployments



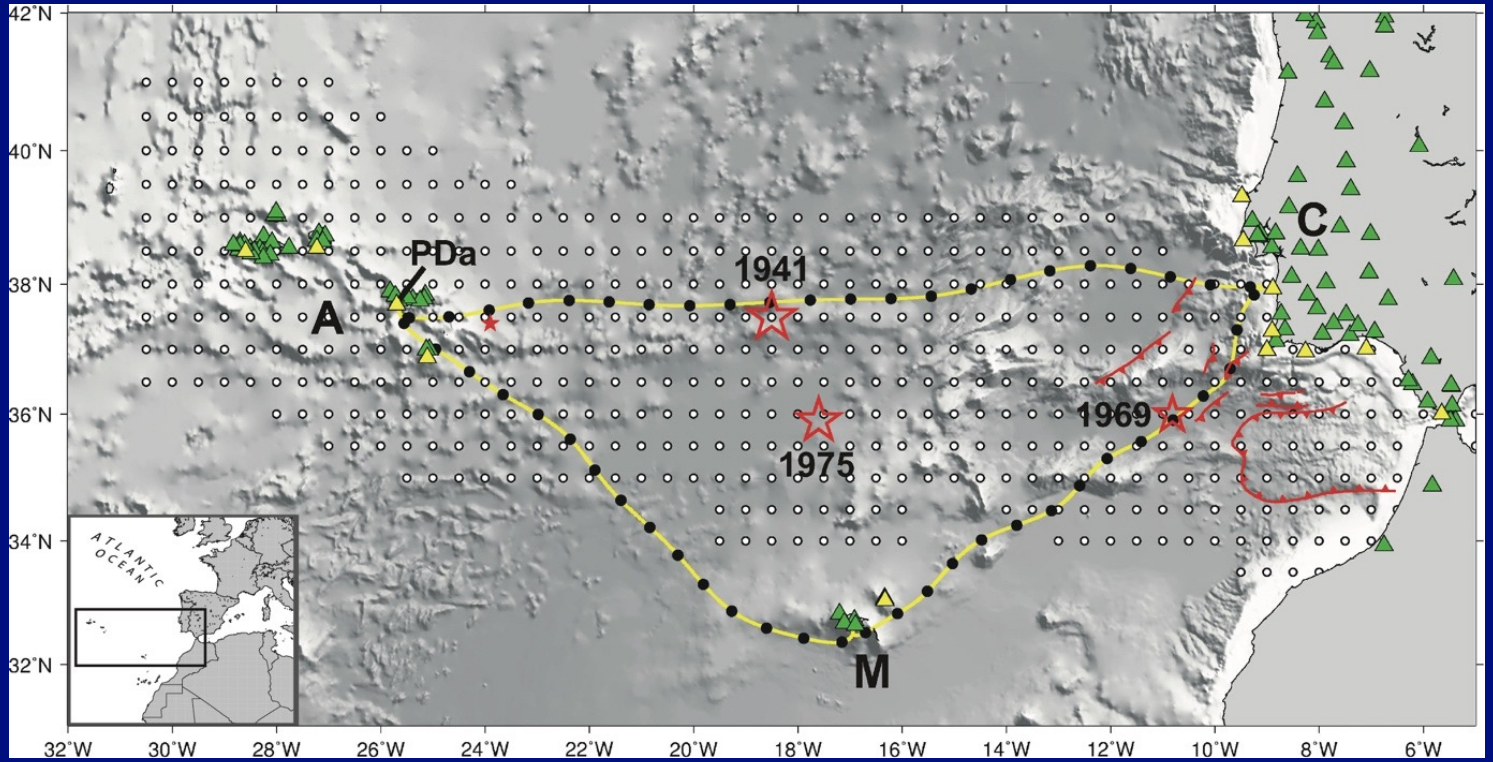
would rely upon standardization for economies of scale, smaller, local deployments such as the demo projects discussed here could incorporate customization, such as hydrophones, externally connected broadband seismometers, and so forth.

SMART projects in planning, preparation, or underway

- The Initiatives in Supporting the consolidation and enhancement of the EMSO research infrastructure consortium and related Activities (InSEA) (Catania, Italy) (EMSO = European Multidisciplinary Seafloor and water column Observatory)
- Continent-Azores-Madeira (CAM) (Portugal)
- Vanuatu – New Caledonia (Moore Foundation)
- Indonesia
- New Zealand – Chatham Islands
- New Zealand – McMurdo (National Science Foundation)

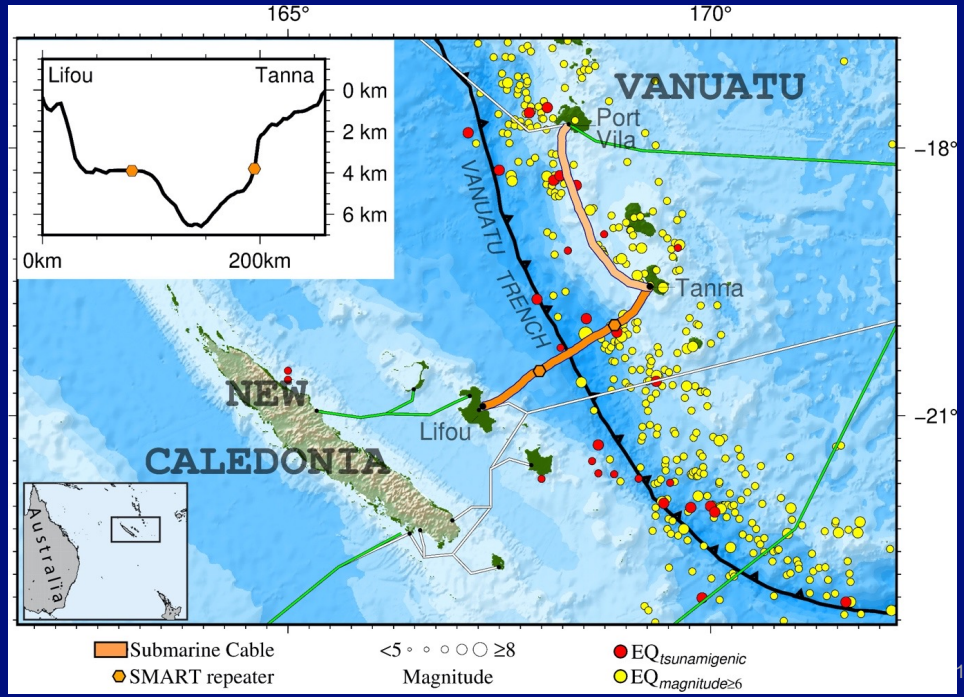
InSEA: In conjunction with other experiments being funded by the Italian government, a prototype SMART Cable will be deployed offshore of Sicily to demonstrate the feasibility of SMART repeaters and sensors, and to validate against stand-alone sensors deployed in nearly co-located hubs.

CAM: This seafloor cable ring will monitor seismic and pressure activity between the Azores, Madeira and the coast of Portugal, including the region that hosted the devastating Great Earthquake and tsunami of 1755. This deployment, scheduled for 2025, will primarily monitor geohazards and serve for early warning.



Vanuatu is the world's most at-risk country for natural disasters (UN World Risk Report, 2016). Earthquake and tsunami risk as well as sea level rise threaten both Vanuatu and New Caledonia. The SMART initiative has received a generous five-year grant from the Moore Foundation to initialize scientific plans for the cables shown here, and other sources of support, including France, the Asian Development Bank and World Bank are currently being negotiated.

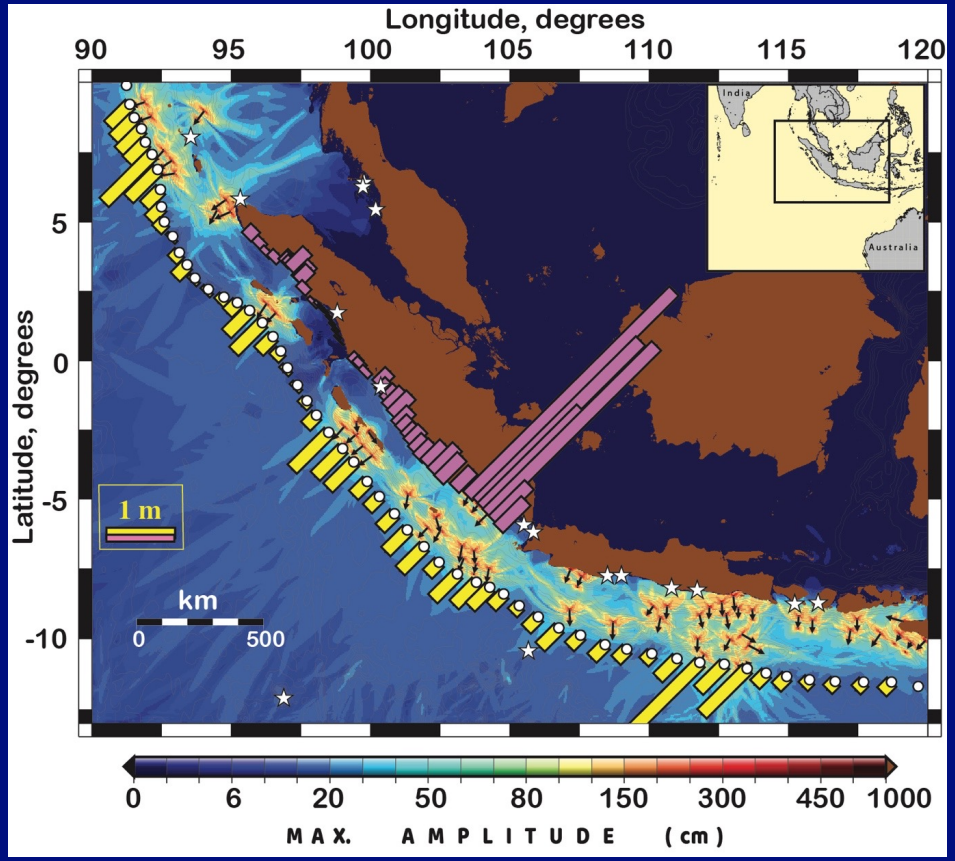
The Moore funds also support the International JTF SMART Project Office, which will coordinate with the International Telecommunications Union JTF secretariat in Geneva to facilitate individual projects.



The International JTF Project Office is tasked with activities that include:

- Work through our sponsoring UN agencies for further member state endorsement, facilitating more engagement (e.g., ITU SMART Resolution, Study Group; IOC Assembly; UN Decade of Ocean Science);
- Work within the international Framework for Ocean Observing, i.e., IOC/WMO Global Ocean Observing System (GOOS), IOC Tsunami Programme, UN Decade, including legal aspects;
- Develop relationships with international and regional telecom regulatory and operator organizations, to trickle down to national levels (e.g., facilitated by Portugal and the Community of Portuguese Language Countries, CPLP);
- Further develop relationships with multilateral development banks and other funding sources;
- Proactively, within each country and internationally, connect with key stakeholders and educate them so that they will support domestic, regional, and global scale projects when opportunities arise;
- Start a data management activity to coordinate activities across various SMART cable projects; and
- Encourage capacity building.

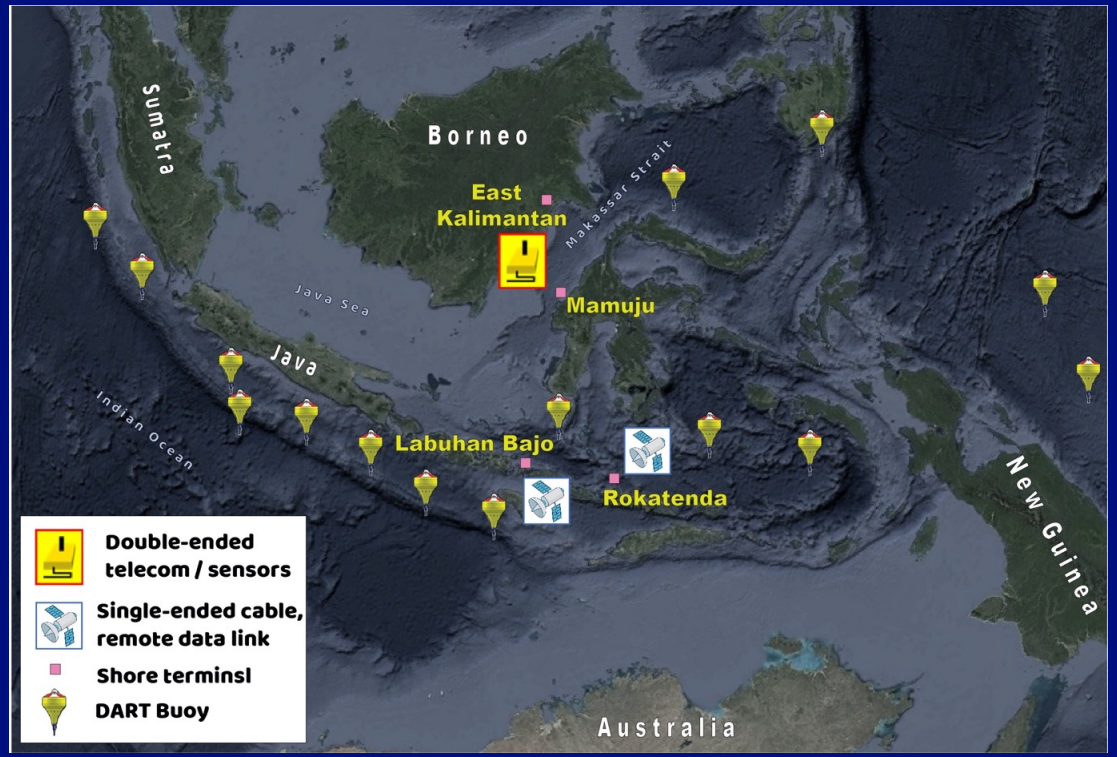
Indonesia is one of the most active earthquake regions in the world, and lies above three converging continental tectonic plates, namely: Indo-Australia to the west and south; Eurasia from the north; and the Philippines plate from the east. Indonesia is therefore highly vulnerable to tectonic earthquakes, volcanic eruptions, and underwater landslides that could trigger tectonic, non-seismic, or complex tsunamis, and is accordingly threatened by far- and near-field tsunamis



Modeled tsunami heights offshore and onshore from a suite of submarine landslides; based on bathymetry.

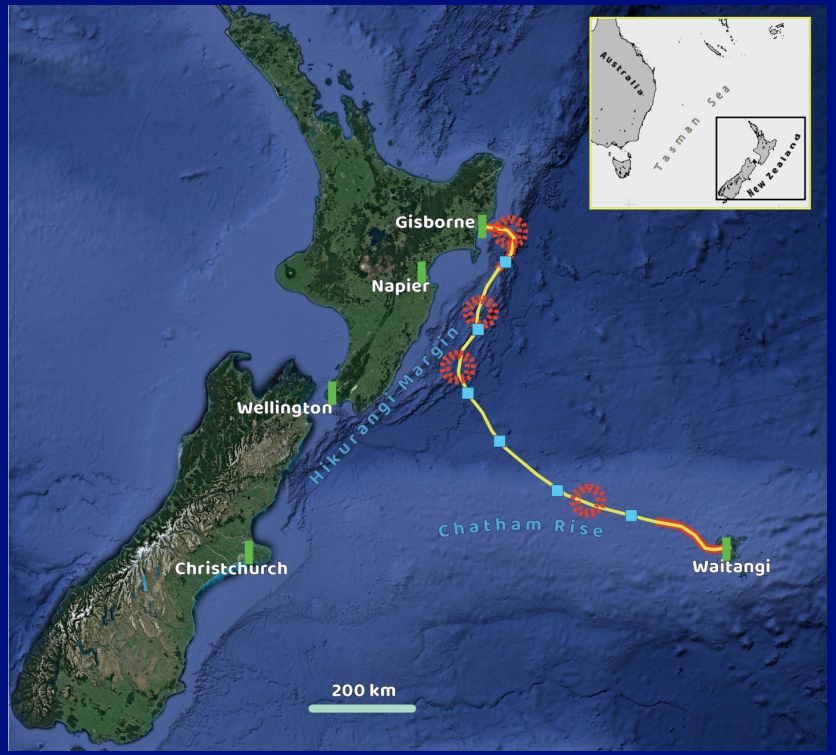
Indonesia plans to implement prototype cable systems both in single-ended (data from sensors only) and double-ended (telecom across Makassar Strait plus SMART sensor nodes).

The Indonesian system will augment a series of existing and planned Deep ocean Assessment and Reporting of Tsunamis (DART) buoys implemented after the Aceh tsunami of 2004. Earthquake monitoring and early warning, and tsunami early warning, can ultimately be benefited by an extension of coastal cable systems

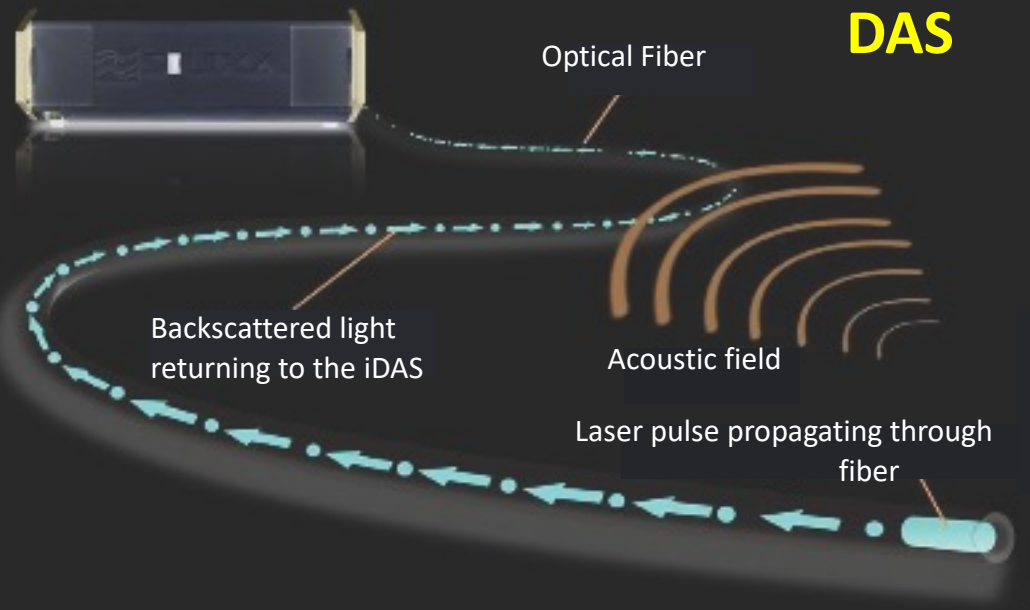


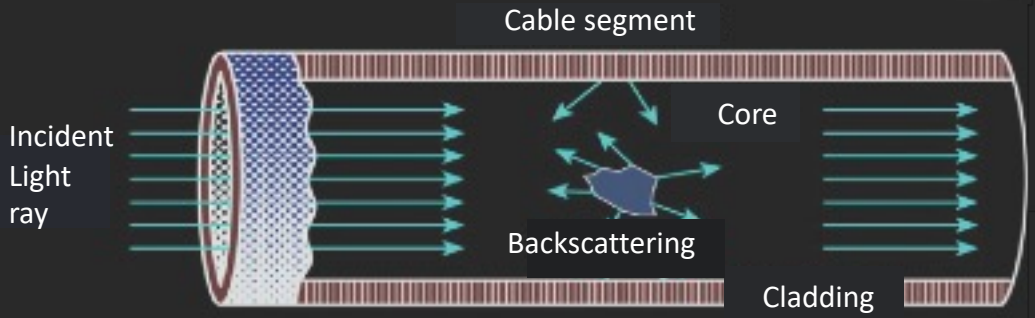
New Zealand – Chatham Island SMART Cable plans: A telecommunication link between the Chatham Islands an the islands of New Zealand was the subject of a 2021 workshop to explore how this need could be linked to the importance of earthquake and tsunami monitoring for the region. The conclusion of the workshop was that both a SMART type system with inline instrumented SMART repeaters, and external branching connectors to host additional geophysical sensors, would best suit these needs. Additionally, extra fibers would be incorporated to leverage DAS near the landing points of the cable.

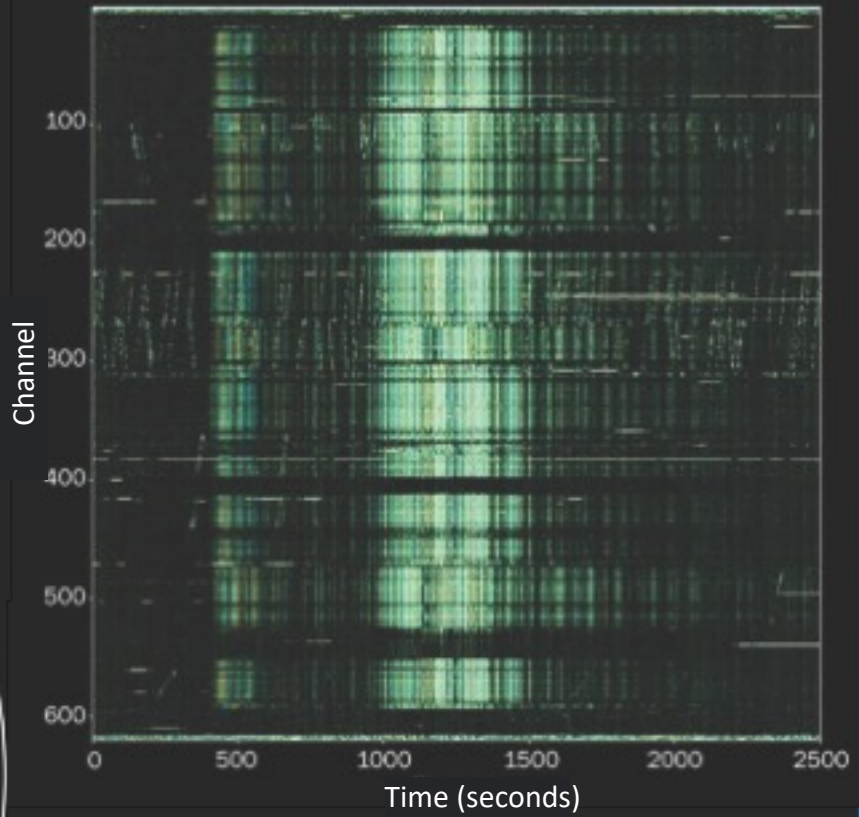
This effort is being spearheaded by the New Zealand Institute of Geological and Nuclear Sciences (GNZ).



DAS







Distributed Acoustic Sensing (DAS). This is a technique that leverages the effect of axial strain on a fiber optic system in order to monitor such physical transients as temperature, pressure or acoustic wave propagation.

DAS Strengths and Weaknesses:

Pros:

A very detailed image of the seismic or acoustic wavefield can be recovered with unprecedented resolution

Data density allows for such leverage as application of array measures or techniques used in exploration (active source) processing to improve detection and reduce relative noise

Can provide critical near-shore resolution for early warning

Cons:

The data volume can be problematic

DAS technology currently only has a distance capacity of about 150 km, so cannot be applied across the entire cable without additional hardware throughout the cable length

Likely a customized feature and not part of ubiquitous COTS units.

The United States National Science Foundation has begun exploring the possibility of installing fiber-optic cable from New Zealand to McMurdo Station in Antarctica. In October 2021, a workshop was convened to begin discussions and outline the need and requirements for such a system.

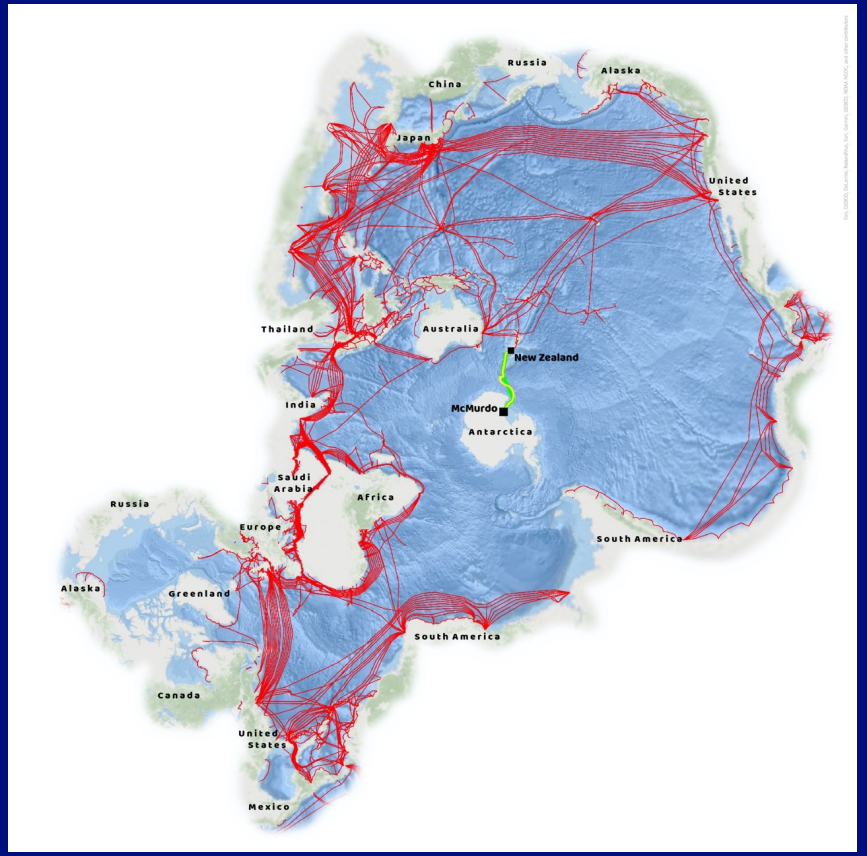
This cable would vastly improve telecommunications and data transfer capacity from Antarctica (currenly reliant upon band-limited satellite links) and afford the opportunity to build a vast array of oceanographic, geophysical, biological and chemical sensors into a permanent seafloor observatory.

Plans were discussed to offer branching nodes for additional experimental operations and sensors.

Proposed route for NZ-MCM SMART Cable, highlighting the overall paucity of systems in the Southern oceans and the importance of this potential sensor installation.

Acoustic sensors are explicitly being discussed for monitoring of sea ice behavior and marine mammals.

A cable is also being considered by Chile, from Puerto Williams to King George Island, and systems are also in various stages of planning for the Mediterranean, from India to Oman, in French Polynesia, and from Australia to Malaysia.



Summary

SMART Cables are becoming a reality, and have the potential to revolutionize submarine oceanographic and geophysical sensing

Pilot / demonstration projects are underway to test the technology and explore the feasibility of incorporating both in-repeater standardized sensor packets but also ancillary sensor types on external, branching nodes.

The projects currently in planning will set the standard and influence the norms for the future of SMART systems

The interest of all potential stakeholders and users, and input as to needs and concerns, is welcomed as testing proceeds.